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Results of a fall prevention educational intervention for residential construction

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ABSTRACT

Falls from height remain the leading cause of fatalities in residential construction. We used results from a comprehensive needs assessment to guide changes in fall prevention training in a joint union-contractor carpenter apprenticeship program; including surveys of 1018 apprentice carpenter and observational audits at 197 residential construction sites. The revised training utilized hands-on, participatory training methods preferred by the learners to address the safety gaps in the curriculum; including ladder use, leading edge work, truss setting, and use of scaffolding and personal fall arrest. We compared apprentice surveys (n = 1273) and residential worksite audits (n = 207) 1–2 years post-training with baseline measures. Apprentices working residential construction were more likely to fall from heights (OR = 2.26, 95% CI 1.59–3.21) than those working commercial construction. The revised training resulted in improved fall safety knowledge, self-reported worksite behaviors, risk perceptions, and safety climate, even after adjusting for temporal trends. We also observed significant improvements in fall safety compliance in most domains of the worksite audit, with larger changes observed in areas emphasized in the training, demonstrating specificity of the effect. Greater effects were noted in small and medium-sized contractors, who often have limited resources to devote to safety. Self-reported falls fell from 18.2 to 14.5 per 100 person-years of work. This research supports growing evidence that worksite safety can be improved by training. This curriculum could be readily adapted to other union apprenticeship programs. Fall safety of inexperienced residential construction workers' should remain a focus of future research.

1. Introduction

Falls from heights remain the leading cause of construction worker mortality and morbidity in the U.S., accounting for 40% of all fatalities and 20% of the days away from work in 2010 (Bureau of Labor Statistics, 2014a). Despite working at lower elevations than workers constructing high-rise buildings or bridges, one-third of the construction worker fall fatalities in 2010. Ladders are the most common piece of equipment involved in fall fatalities (Bureau of Labor Statistics, 2012). Among residential construction workers, ladder falls accounted for 16% of the fatalities in 2007, 20% in 2008, and 26% in 2009 (Bureau of Labor Statistics, 2014b). After evaluating the worksites of 95 carpenters who fell while working at a residential site over a 3-year period, Lipscomb and colleagues determined that conventional fall protection could have prevented many of the falls (Lipscomb et al., 2003), but such protection was rarely in place. At the time, OSHA's Residential Guidelines allowed alternative methods if conventional fall protection methods were deemed infeasible. However, many of these alternative fall prevention methods were practiced inconsistently in residential construction (Kaskutas et al., 2008), exposing workers to high risk activities. For example, at two-thirds of the worksites audited it was common to see workers walking on the narrow top of a 2-story wall in order to install roof trusses – an inherently dangerous activity (Kaskutas et al., 2009). Failure to follow fall

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prevention methods identified in a worksite plan is common in the United States and abroad, with reasons including lack of safety knowledge and competence among workers, lack of management support, and subcontractor lack of cooperation (Goh and Goh, 2016).

Inexperienced construction workers are especially vulnerable to workplace falls, as are temporary workers, non-fluent speakers, and employees of small construction firms (CPWR – The Center for Construction Research and Training, 2013). This paper describes results from an apprenticeship training program targeting inexperienced residential construction workers. A multi-faceted needs assessment identified gaps in the curricular content (Kaskutas et al., 2010a) and apprentice-preferred training methods (Kaskutas et al., 2010b), which echoed results from other construction worker populations (Lipscomb et al., 2008). The training utilized high engagement training methods, such as hands-on practice, simulations, and reality-based training; with limited use of passive information-based methods such as lectures, handouts, and videos. Apprentice survey and residential worksite audit results administered during the needs assessment were compared to results one and two years after implementation of the revised residential fall prevention training. We hypothesized that fall prevention behaviors at residential worksites, and apprentice carpenters' knowledge, risk perceptions, and safety climate would improve following implementation of the revised apprenticeship training.

2. Methods

2.1. Site of work and needs assessment

This study was performed between 2004 and 2009 with the Carpenters Joint Apprenticeship Program in St. Louis, a carpentry training program operated in collaboration between the carpenters' union and local home builders. In addition to evaluating the timing, content, and teaching methods of pre-intervention training, we conducted surveys and focus groups with a cross-sectional sample of apprentice carpenters to measure fall prevention knowledge, reported worksite behaviors, risk perceptions, confidence ratings, and safety climate, as well as observed fall safety practices at the new home construction sites. Results of the focus groups (Lipscomb et al., 2008) and surveys (Kaskutas et al., 2010a) have been previously reported.

2.2. Intervention development and implementation

Results from the needs assessment were organized to identify common unsafe work behaviors and misconceptions, the timing of task training versus on-the-job task performance, and preferred learning methods. For example, workers often reported working at heights before receiving fall training on the job or through the apprenticeship, and ladders were not perceived by apprentices as posing a high risk for falls despite being the most common equipment involved in a fall. Results of the needs assessment were shared with the apprenticeship trainers and a core group of trainers reviewed the existing fall prevention curriculum and revised the training to meet the identified needs using teaching methods preferred by this population, including participatory learning and active engagement. Working with the research team, carpenter instructors created detailed learning objectives and lesson plans, actively engaging learning experiences, and contextually-relevant examples and equipment. In order to demonstrate different fall prevention techniques, a teaching "prop" of a partially constructed home and a roof truss assembly were built. A variety of anchors and harnesses for personal fall protection, scaffold systems, and supplies for a fall simulation were purchased. Apprentices practiced applying safety harnesses, setting ladders and scaffolding, and observed the benefits of retracting lifelines. Risk perceptions were explored through group sorting of construction site pictures, shared stories, and small group problem-solving. Lectures, printed materials, and videos were followed by application to real-world situations. The revised curriculum targeted four areas identified in the gap analysis: ladders, leading edges and openings, truss setting, and personal fall arrest systems (PFAS). Elements of the curriculum were presented at several stages of the apprenticeship, building on principles learned as the apprentices gained real-world experience. Details of the gap analysis, curriculum development, and the intervention have been reported previously (Kaskutas et al., 2010b).

Process evaluations of the new curriculum were administered to solicit apprentice feedback and determine utility of training methods; both surveys and focus groups were used. Fidelity of the intervention was monitored throughout the study using instructor logs to track achievement of learning objectives each time the training was delivered. The curriculum was formally rolled out in April 2007, with curricular adjustments made based upon results of ongoing process evaluations.

2.3. Outcome measurements

In order to measure effects of the training, we surveyed all apprentices attending bi-annual training at the apprenticeship school during the measurement period, and conducted fall safety audits of residential construction worksites employing one or more apprentices. Apprentice surveys and worksite audits collected for the needs assessment served as pre-intervention baseline measures. Follow-up surveys were repeated 12–27 months following initiation of the new curriculum; follow-up worksite audits were performed 12–17 months after initiation of the intervention. The apprentice survey included questions about carpentry experience, fall prevention knowledge, ratings of fall risk perception for 12 different work situations (0–10 scale), past fall prevention training, confidence in ability to avoid falling at work (4-point agreement scale), self-reported crew behaviors (5-point frequency scale), perceived workplace safety climate (5-point agreement scale), and recent falls. A fall was defined as "falling from one height to another, like falling from a ladder or down several steps, but not a fall to the floor on which you are standing." In order to understand the severity of injuries sustained in the fall, respondents who had experienced a fall were asked if they received medical care or prescription medications, were placed on light or restricted work, or lost work time beyond the day of the fall. We have previously described the development of the apprentice survey, measures of scale reliability, and baseline results (Kaskutas et al., 2010a). For this study, analyses were restricted to surveyed apprentices who had worked in construction during the preceding year.

The St. Louis Audit of Fall Risks (SAFR) was developed to measure worksite behaviors at residential construction sites. We reviewed construction-specific worksite audits used in previous research, OSHA's construction standards (Occupational Safety and Health Administration, 2006), and Interim Guidelines for Residential Construction (Occupational Safety & Health Administration, 1999), and solicited feedback from a panel of expert carpentry professionals. This audit computed scores based on 52 dichotomous response items in nine domains: general safety, floor joist installation, wall openings, floor openings/edges, roof truss installation, roof sheathing, scaffolds, ladders, and personal fall arrest systems (PFAS). A short worker interview was also performed at the time of the audit. Two retired journeymen carpenter research assistants with prior experience in residential construction and safety